Aberration considered in relation to the two Star-Streams.

By A. S. Eddington, M.A., M.Sc.

The suggestion here considered with regard to the two star-streams which appear to exist throughout the sky was made to me by Mr. Stratton nearly two years ago, and recently and independently by Professor Turner.* I believe that the result of examining the data of the observed proper motions is to show that it is not a correct explanation of the phenomena; but it seems worth while to publish it, not only on account of its intrinsic interest, but because the published investigations of the systematic motions of the stars hardly afford a means of testing it, and it is only by reference to the original data that we are able to ascertain whether it is or is not accordant with the facts.

The suggestion (practically in Professor Turner's words) is as follows :—

(*a*) The Sun's motion in space gives rise to an aberration effect, which, however, is usually neglected. The displacement of the stars from this cause is constant, and we may as well use the displaced as the true places.

(*b*) But if the solar motion were to change, there would be a change of this aberration displacement. An *acceleration* of the Sun would produce, by aberration, changes in the apparent positions of the stars very similar to those which its *velocity* produces by displacement; with this difference, however, that the aberration effect would be independent of the stars' parallaxes, whereas the displacement effect depends on them directly.

(*c*) Were it not for this difference, the effects of the two vectors (α) displacement and (β) change of velocity would compound, according to the vector law, and be inseparable by observation.

(*d*) But the difference specified in (*b*) gives an independent existence to the two vectors; so that, in a sense, the Sun has two apparent velocities relative to the stars.

(*e*) Is this a possible explanation of the two star-streams? The attractiveness of the explanation lies in the accounting for the complete intermingling of the two streams. The duplicity is in fact removed from the stars to the Sun.

Consider, for example, in a universe in which the true motions of the stars are everywhere haphazard, the two groups of stars which are respectively (1) very near to the Sun and (2) very distant from it. For the former the displacement effect (which is proportional to the parallax) will be great in comparison with the aberration effect, so that the latter effect may be neglected. This group of stars will accordingly appear to form a drift, whose motion relative to the Sun would be parallel to and opposite to the true solar displacement. On the other hand, for the very distant stars the displacement effect will be vanishingly small; and assuming the aberration effect to be sensible, that will be the only change of

* *Monthly Notices*, lxix. p. 412, sec. 22.

position observed. These stars will accordingly appear to form a drift moving parallel to the direction of the solar acceleration. When the stars intermediate between these two extremes are taken into consideration, the division into two drifts will be theoretically less marked; but it is clear that we can in this way account for the two "favoured directions of motion," and there seems no reason to doubt that the main features of the distribution of the directions of motion of the stars would be satisfactorily explained by this theory.

It is, however, possible to apply a crucial test, which will determine whether the double star-stream phenomenon arises from the cause suggested. Suppose that, as usual, the proper motions of stars in a small area of the sky are considered. For all these, the aberration effect will be a sensibly constant though unknown angular amount, since it is independent of the parallax, and depends only on the position on the celestial sphere. Let it be u'' per century in R.A. and v'' per century in Dec. If then we correct all the observed proper motions by the amounts $-u''$, $-v''$, the aberration effect will be eliminated completely, and the residual proper motions should no longer show any evidences of the two streams. The question is—Can we for any region find values of u and v for which this is the case? (It will be seen that the aberration effect is equivalent in any one region to a systematic error in the proper motions.) In order to test this, I made use of diagrams constructed as follows: each proper motion whose components are x'', y'' is represented by a dot at the point whose cartesian coordinates are (x, y). These diagrams were made for several of the regions of the Groombridge proper motions. The same diagram will be made to represent the corrected proper motions $x''-u''$, $y''-v''$, by merely shifting the origin to the point (u, v). Thus, by regarding the origin as arbitrary, we can allow for the application of the correction for the aberration effect of any arbitrary acceleration of the Sun. But in the diagrams two features were noticeable: (1) the two streams were conspicuously evident in the distribution of the dots, even when the origin was omitted from the figure altogether; (2) the origin is not really arbitrary, but is fixed with certainty to within about 1″ per century by the tendency of the dots to agglomerate closely about one point, this point being practically coincident with the position of the origin used in drawing the figure.

As regards the feature (1), the recognition of the two streams in a diagram of this kind is perhaps a matter in which individual bias may play some part. If anyone wishes to see for himself a diagram of this kind, reference may be made to Professor Dyson's paper, "The Systematic Motions of the Stars" (*Proc. Roy. Soc. Edinburgh*, vol. xxviii., part iii., p. 232). The diagram 1 is constructed in this way, but the space around the origin (corresponding to the small proper motions) is left blank, whereas for our purpose it should be imagined to be filled with very numerous dots—three thousand at least. I think an examination of that figure will show that no change in the position of the origin can get rid of or in any way

affect the appearance of the two streams, which are so well shown in the distribution of the dots.

As regards feature (2), there can be no difference of opinion in fixing (to within the limits stated) on the point about which the dots aggregate most closely; and the fact that this always coincides approximately with the adopted origin shows that the proper motions in the region are not affected by a systematic error of more than about 1″ per century, whether arising from aberration or from any other causes.

It may be noted that the existence of an acceleration of the Sun great enough to produce an appreciable aberration effect of the kind discussed would be difficult to account for by any distribution of gravitating matter in the universe reconcilable with our present knowledge.

On Some Points with regard to the Light Fluctuation of Variable Stars. A Rejoinder to Mr. H. C. Plummer's Criticisms. By Karl Pearson, F.R.S.

(1) The purport of my original paper "On Some Points with regard to the Light Fluctuation of Variable Stars," *Monthly Notices*, vol. lxix. p. 128, was twofold. In the first place, I desired to draw the attention of astronomers to the new instruments of research put at their disposal by the methods of modern statistics; and in the next place, to indicate that these methods applied to variable star problems suggested not a few lines of observational inquiry, and possibly modification of opinions already formed. My paper concluded with the words: "I will not venture to be dogmatic about a single conclusion or constant given in this memoir. As a statistician, I am painfully conscious of the dangers of small samples. But certain points have, I think, been indicated, which are worthy of the attention of astronomers."

It will be seen that I was fully conscious of the smallness of our present knowledge in this field, and wished my paper to be regarded as one of suggestion. Mr. Plummer's description of it as "the mere accumulation of a mass of uncoordinated material, and the indiscriminate volley firing . . . . of a statistical method," is, I venture to hold, rather too sweeping. I am not prepared to accept the view that even existing material, slender as it is, may not provide valuable results, treated by the new methods, and would cite recent papers by Dr. Charlier, Professor Turner, and Father Stein to confirm my opinion.

The main criticism of Mr. Plummer, however, does not turn on the material used; it turns on a supposed blunder in theory, and is discussed in §§ 3 and 4 of his paper. Had he approached me for an explanation of the supposed paradox, I think a few minutes' conversation would have modified his standpoint, and